Studies on the Use of Electrolyzed Water as a Disinfectant at Home Care

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***Abstract*—The prevention of opportunistic infection for the elderly is important in home care and the hygiene management for infection is required. When water containing sodium chloride is electrolyzed, electrolyzed water with strong bactericidal ability due to the available chlorine (AC) is generated on the anode side. Slightly acidic to neutral electrolyzed water (SANEW, pH 5.0 to 7.5) is physiological pH and is suitable for biological applications. For producing SANEW simply and at a low cost, the container has electrolysis cell in a cylindrical shape having a sidewall without membrane partition and the sidewall serves as a cathode in the electrolyzer device. The graphite rod was used as the anode. As a result, the pH and AC concentration were 5.6 and 13.7 ppm, respectively. SANEW was obtained directly by this experimental device and this water showed a strong bactericidal activity. This device is useful for producing SANEW as a disinfectant to employ at home care, when considering economic and environmental factors, since it returns to ordinary water after use.**

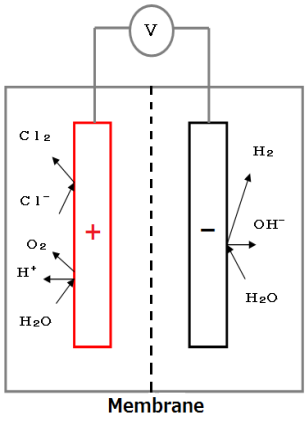
Keywords- Home care; Electrolyzed water; Bactericidal activity.

I. INTRODUCTION

The prevention of opportunistic infection due to a reduction in resistance or physical strength of the elderly is important in home care and the hygiene management for infection is required. Electrolysis is known as a method of separating an ionic substance by way of a chemical reaction. A device for achieving electrolysis requires certain components, such as an electrolyte containing an ionic substance, a pair of electrodes (an anode and a cathode), a diaphragm and a direct electric current supply. In the electrolysis process, water containing sodium chloride (NaCl) is electrolyzed, resulting in the production of strongly acidic electrolyzed water (SAcEW, pH 2.2 to 2.7) on the anode and strongly alkaline electrolyzed water (SAlEW) on the cathode side (Fig.1). SAcEW contains an available chlorine (AC) such as hypochlorous acid (HClO), which is known to have a strong bactericidal action and shows an instantaneous bactericidal activity [1] [2]. SAcEW reverts to ordinary water again after use. Therefore, recently this water has attracted considerable interest in a medical field.

However, the activity does not persist. In addition, SAcEW stimulates the oral mucous etc. because of its strong acidity, and is therefore unsuitable for biological applications [3][4]. On the other hand, in slightly acidic to neutral electrolyzed water (SANEW, pH 5.0 to 7.5), since the activity persists and its pH is physiological levels, it can be applied to various uses. However, the production of SANEW requires electrolysis of hydrochloric acid itself or use of hydrochloric acid as a pH adjuster. Thus, the production is too complicated to perform in domestic homes.

In this study, we developed a simple device to produce SANEW directly for home care without use of hydrochloric acid and evaluated the bactericidal activity of this solution.



Anode side

$H_2O \rightarrow 1/2O_2 + 2H^+ + 2e^-$

$2Cl^- \rightarrow Cl_2 + 2e^-$

$Cl_2\ (aq) + H_2O \leftrightarrows HCl + HClO$

Cathode side

$H_2O + 2e^- \rightarrow 1/2H_2 + OH^-$

$Na^+ + OH^- \leftrightarrows NaOH$

Figure 1. Principle of producing electrolyzed water with two electrolytic cell

This paper is structure as follows. Section II describes the device used as well as the approach to measure

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bactericidal activity. In Section III, we present the results. In Section IV, we discuss the relevance of the results. Section V concludes the paper.

II. METHODS

A. Device

The most expensive in the electrolyzer device is an electrode which is coated by platinum for the protection against corrosion. In order to reduce the cost, the container was electrolysis cell in a cylindrical shape having a sidewall without membrane partition. The sidewall was made of stainless steel and was operatively connected to a DC power supply so that the sidewall serves as a cathode in the electrolyzer device. The graphite rod was used as the anode. As the graphite rod was arranged as the anode in the vicinity of a center of the container, the anode was surrounded by the cathode at a constant distance, and thereby the strongly alkaline electrolyzed water will be obtained at the vicinity of the sidewall of the container (Fig. 2).

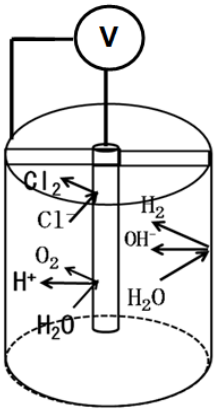

Figure 2. Principle of producing electrolyzed water with a cylindrical shape

B. Measurement

Using an experimental device, 1L of 0.1% NaCl solution was put into a container and electrolysis is performed by applying a DC 20 voltage for 30 minutes. The values of the pH and AC concentration of the electrolyzed water were measured with diethyl-p-phenylenediamine by a spectrophotometer.

C. Bactericidal activity

Two strains of bacteria (*S.aureus* and *B.cereus*) were prepared to investigate the bactericidal activity of electrolyzed water. The bactericidal activity was examined as follows. These bacteria were cultivated at 37°C for 24 hours under aerobic-culture in petri dishes. After cultivation, each one colony was incubated with 10% povidon iodin, 70% isopropyl alcohol, SAcEW and SANEW, also this solutions were added onto the fresh petri dishes and were cultivated for 48 hours. The colony of bacteria in the petri dish was counted and the bactericidal activity was judged.

III. RESULTS

The obtained measurement results, the levels of pH and AC concentration of the extracted electrolyzed water at 30 minutes after the start of the electrolysis are listed in Table 1. The levels of pH of those water were from 5.5 – 5.9 and those of AC concentrations were from 11.1 – 13.7 ppm. SANEW was obtained directly by this experimental device.

The results of bactericidal activity of chemical disinfectants and electrolyzed water are shown in Table 2. There were many colonies of *S. aureus* and *B.cereus* in each petri dish as controls, while there was no colony of bacteria after added SANEW as same as other solutions.

TABLE Ⅰ. THE LEVELS OF PH AND AC CONCENTRATION OF ELECTROLYZED WATER

	pH	AC concentration (ppm)
Electrolyzed water	5.9	11.2
	5.6	13.7
	5.6	13.0
	5.5	11.1

TABLE Ⅱ. BACTERIAL ACTIVITY OF ELECTROLYZED WATER

Bacteria / Solutions	*S.aureus*	*B.cereus*
Control (Sterilized water) CFU/ml	16.6×10^6	67×10^5
10% povidon iodin	0	0
70% isopropyl alcohol	0	0
SAcEW	0	0
SANEW	0	0

IV. DISCUSSION

Generally, in an electrolyzed water generator having a membrane, equal amounts of acidic water and alkaline water are generated in the respective electrolytic chambers with the same capacities on both sides of the membrane. Consequently, SANEW cannot be directly produced. Alternatively, a system for producing SANEW by a method using hydrochloric acid as a pH adjuster with a membrane-less system suffers from the problem of handling hydrochloric acid.

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SANEW has strong bactericidal activity against *E.coli* and *B.cereus* similar to chemical disinfectants and also, it has an advantage that its bactericidal activity stably persists for a long time, making it useful for sterilization, disinfection and cleaning as same as SAcEW with pH 2.2 [5]. Accordingly, it is applicable to electrolyzed water generators producing bactericidal water that can contribute to killing bacteria on equipment and utensils in food factories, sterilization of instruments in medical-related departments, care homes for the elderly, cleaning toilets and the interiors of buildings, and cleaning bathrooms. Furthermore, since bactericidal water can be simply generated and returns to ordinary water when discarded, the present study is easy to use for improving public hygiene.

The present study is characterized in that electrolysis cell in a cylindrical shape having a sidewall serves as a cathode, and does not need to maintain for membrane replacement. The structure is a simple one that does not need any special tool. This apparatus can be made at a low cost about 1/10 times as compared with conventional apparatus using hydrochloric acid [6]. Therefore, this device is useful for producing SANEW as a disinfectant to employ at home care. However, as a disadvantage, the graphite rod elutes very slightly during electrolysis by DC 20 V and needs to be replaced with long term use. And also, the quantity of SANEW production is 1L/30 min because of a batch type specification, which is rather low compared to the conventional apparatus of flowing water type (5L/min). Further research is necessary to make an improvement in this apparatus.

V. CONCLUSION

We made a simple electrolytic device in cylindrical shape having a sidewall and succeeded to produce SANEW with strong bactericidal ability as a disinfectant. SANEW can be produced from a saline solution and at a low cost in this system. This device is useful in home care.

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